Comparison of selected methods for relative assessment of surface charge on waste sludge biomass

F Bux[1] and HC Kasan[2]*
'Department of Microbiology, University of Durban Westville, Private Bag X54001, Durban 4000, South Africa
department of Biotechnology, Technikon Natal, PO Box 953, Durban 4000, South Africa

Abstract

Industrial pollution has directed much concern about contamination of fresh-water systems by metal-laden effluents. Research has shown that activated sludge has potential for the removal of heavy metals from contaminated effluents. Much of the biosorptive capacity of the sludge may be attributable to the net negative charge present on the sludge surface, thus facilitating binding to positive metal cations. Detection of surface charge may serve as an excellent indicator of the adsorption potential of sludges and other potential biosorbents. Ten waste activated sludges were screened for surface charge using 3 different methods, viz., streaming current method, millivolt quantification method and the colloid titration technique. All 3 methods were capable of detecting surface charge and facilitated ranking of 10 sludges on the basis of electronegativity. Although charge determination using the titration method has most frequently been used, the millivolt quantification technique proved to be a more feasible and applicable method to detect surface charge of suspended sludge solids. The results from 3 methods employed showed that the sample from Southern Works, S9, was most electronegative.

Introduction

Activated sludge biomass is composed of eubacteria, filamentous bacteria, fungi, yeast, algae and protozoa (Jenkins et al., 1986; Bux et al.,1992; 1993). Several studies have shown that the activated sludge treatment process is capable of reducing metal-ion concentrations from waste-water (Brown et al., 1973; Chen et al, 1974; Lester et al., 1983; Fletcher and Beckett, 1987a). Many workers have attributed this finding to physico-chemical interactions between metal ions and sludge surfaces (Stoveland and Lester, 1980; Sterrittetal., 1981; Fletcher and Beckett, 1987b; Lake et al.,1989). Sludge surfaces are polymeric in nature comprising of protein, carbohydrate, nucleic acids and lipid (Goodwin and Forster, 1985). Sludge biomass is negatively charged due to the ionisation of inorganic groups such as carboxylic, aliphatic, aromatic, hydroxyl, sulphate and amino groups (Hughes and Poole, 1989).

Recent findings have conclusively shown that waste activated sludges from a variety of sources are capable of biosorbing several metal-ion species from solution (Swalaha and Kasan, 1992; Kasan, 1993). Since the biosorption of metal cations to sludges is dependent on the sludge surface charge, the objective of this study was to determine the relative charge on 10 waste activated sludges via comparison of 3 different methods, viz. streaming current, millivolt quantification and colloid titration techniques.

Materials and methods

Grab samples of return activated sludge were obtained from waste-water treatment plants in Natal, namely: Umlaas, S1; Amanzimtoti, S2; New Germany, S3; Hammarsdale, S4; Pietermaritzburg, S5; Kwa Mashu, S6; Tongaat, S7; Northern Works, S8; Southern Works, S9 and Phoenix, S10. Sludges were concentrated to 25 000 mgl-1 by centrifugation using a J6B Beckman centrifuge at 3 500 x g for 30 min and pellets were resuspended in 100 *ml* deionised water in sealed bottles and stored at 4°C for further use. The electronegativity of the sludge particles was determined within 48 h of obtaining samples utilising different methods, i.e. streaming current method, use of a pH/millivolt meter and modification of a colloid titration technique as described by Kawamura and Tanaka (1966).

Streaming current method

The movement of like charges is defined as an electrical current. This current is called the streaming current. The streaming current monitor utilises the principle of streaming current to obtain a measure of the colloidal charge and the values vary linearly with temperature. Streaming current is related to the zeta potential as follows (Smith and Somerset, 1971):

$$i \propto \frac{ZD}{N}$$

where:

i = streaming current
Z = zeta potential
D = dielectric constant
N = viscosity of fluid

Sludge samples S1 to S10 were diluted to a final volume of 100 *ml* and standard concentration of 5 000 mg-fr' using deionised water. The procedure involved using a Chemtrac Model 2 000 x R streaming current monitor (Floccotan, SA). The unit was initially flushed for approximately 15 min with distilled water and subsequently standardised with deionised water. A 50 *ml* syringe was used to inject sludge samples into the boat of the monitor. Results were recorded when constant negative streaming current values were acquired. This procedure was conducted in triplicate. The instrument was rinsed with deionised water between each of the samples tested.

* To whom all correspondence should be addressed.
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